

Acidification Requirements for Home Canned Combinations of Tomatoes and Low-Acid Ingredients

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ABSTRACT

Alternative methods of estimating acidification requirements for home canned high-acid foods comprising combinations of tomatoes with low-acid ingredients were compared with forty representative products. Acidification estimates were based on recipe specifications, titration data, predictions made with a regression equation derived from a quadratic model, and predictions derived from a worst case analysis of the model. The last method resulted in satisfactory pH reductions (0.2–0.3 unit) even with products having pH values close to 4.6. Acidification recommendations based on the worst case analysis are given for eight categories of high-acid combination products.

INTRODUCTION

THE SELECTION of safe home canning procedures for foods which combine tomatoes and low-acid ingredients is difficult since the choice and proportions of ingredients for such products vary greatly. One aspect of the problem is the determination of whether the product is a low-acid food (pH > 4.6) requiring pressure canning to destroy *Clostridium botulinum* spores or an acid food (pH ≤ 4.6) for which a boiling water bath process is sufficient. Even with combinations shown to be high-acid foods, home canning procedures should be designed with some margin of safety to compensate for unexpected elevation in pH. In previous studies we demonstrated that deficiencies in tomato acidity alone can shift product pH above 4.6 (Sapers et al., 1982b). To compensate for natural variability in acidity, commercial canners may add an acidulant to tomato products to reduce their pH below 4.3, thereby reducing the risk of spoilage as well as eliminating any botulinal hazard (Powers, 1976). Although many home

canning recipes contain acidification instructions, their validity sometimes may be questioned. In this study, we have determined levels of acidification appropriate to important categories of high-acid tomato-based combination products which may fall into a borderline pH range (pH 4.4–4.6).

MATERIALS & METHODS

FORTY RECIPES representing eight categories of high-acid tomato-based products (Table 1) were selected for testing. All products were prepared as described by their recipes, except that specified acidulants (lemon juice, vinegar, and Worcestershire sauce) were withheld from the bulk product and added later in scaled down quantities to individual pint jars of product. An aliquot of each unacidified product, cooled to room temperature, was homogenized, and duplicate 100g portions (diluted with 200 ml distilled water) were titrated with commercially bottled vinegar (5% acidity) to pH 4.4 and then to pH 4.2. The quantity of vinegar required for each endpoint was multiplied by 4.5 to scale-up from 100g to pints (containing approximately 450g), and these amounts were added to pint jars of hot product.

As another approach, the quantity of vinegar required to lower the pH of combinations to 4.4 was predicted with a regression equation derived from a quadratic model representing mixtures of tomatoes and the low-acid ingredients listed in Table 2. The model was constructed by combining these ingredients in different proportions in 758 individual trials, as specified by the experimental design (Sapers et al., 1982b). 100-g portions of pureed ingredients and their mixtures, corresponding to each trial, were diluted with 200 ml distilled water and titrated with vinegar to pH 4.4. These titration data were fitted to the model to generate the regression coefficients of a 19-term equation for predicting the quantity of vinegar required for pH adjustment, given the ingredient proportions in the combination. This quantity of vinegar was calculated for each recipe, scaled-up to 450g and added to jars of hot product.

We also used the vinegar titration data from the model trials to estimate the quantity of vinegar required to reduce the pH of the least acidic and/or most highly buffered product within a category to a value no higher than 4.4. We obtained this estimate by first determining the range of tomato and low-acid ingredient proportions

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Table 1—Determination of acidification requirements for high-acid tomato-based combination products

Product category	Recipes tested	“Worst case” estimation of acidification level					Acidification level by titration ^b		pH Range of tested recipes		Recommended vinegar addition (tbsp/pint)
		Recipes in data bank	Minimum percent tomatoes	Low-acid ingredients ^a	No. of applicable model trials	Maximum acidification level ^b	to pH 4.4	to pH 4.2	Without acidification	With acidification ^d	
Tomato-vegetable juice blends ^c	4	23	33	Ca,Ce,O,P	—	—	0– 7.6	13.6–27.5	4.46–4.56	4.23–4.25	2
Stewed tomatoes	3	16	60	Ce,O,P	24	18.0	0– 6.8	8.6–22.0	4.40–4.56	4.15–4.28	1
Tomato purees and pastes	5	15	71	Ca,Ce,O,P	60	18.9	0– 4.0	5.4–18.9	4.38–4.50	4.21–4.36	1
Tomato sauces, U.S. style	8	32	49	BB,CB,Ca,Ce,O,P	156	21.8	0–13.0	14.4–34.4	4.34–4.66	4.11–4.31	1½
Spaghetti sauces, Italian (meatless)	6	16	33	BB,Ca,Ce,M,O	110	22.5	0–11.7	10.1–46.4	4.44–4.52	4.12–4.40	1½
Marinara sauces	4	7	68	O	6	14.4	0– 9.7	17.6–25.2	4.48–4.62	4.32–4.39	1
Tomato-pepper sauces, Mexican ^c	7	40	26	O,P	24	18.9	0–11.0	5.4–29.0	4.39–4.66	4.15–4.32	1
Barbecue sauces	3	22	23	BB,Ce,O,P	112	23.0	0	10.1–16.2	4.34–4.46	4.13–4.21	1½

^a BB = beef broth, CB = chicken broth, Ca = carrot, Ce = celery, M = mushroom, O = onion, P = pepper (green or red)

^b MI vinegar (5% acetic acid per pint of product)

^c All recipes should be tested to confirm that product pH ≤ 4.6

^d Products acidified at "worst case" level except for tomato-vegetable juice blends which were titrated to pH 4.2

Table 2—Regression coefficients for the prediction of acidification requirements^a

Ingredient	Subscript (i or j)	Regression coefficient ^b	
		β_i	β_{0j}
Tomatoes	0	0.011	—
Ground beef	1	0.115	0.00015
Mushrooms	2	0.056	0.00022
Onions	3	0.029	0.00028
Green bell peppers	4	0.034	0.00010
Celery	5	0.056	-0.00045
Beef broth	6	0.042	0.00000
Carrots	7	0.028	-0.00006
Chicken broth	8	0.067	-0.00003
Red kidney beans	9	0.194	-0.00080

^a ml vinegar (5% acetic acid) per 100g sample to reduce pH to 4.4

^b Based on 758 data points

specified by all recipes within each of the high-acid product categories (Table 1), as listed in our recipe data bank (Sapers et al., 1982a). We then identified all model trials containing two or more of the same ingredients specified by these recipes and approximating their proportions. The trial requiring the largest addition of vinegar to reduce the mixture pH to 4.4 was taken as the "worst case," and this quantity was scaled-up to 450g and added to jars of product.

Duplicate pint jars of products acidified by each method as well as unacidified controls were sealed and processed in a boiling water bath for 55 min (after the resumption of boiling). The processed products were stored at room temperature for 1 month (unacidified controls were refrigerated to prevent spoilage) before being examined. After storage, products were homogenized in a Waring Blendor for 30 sec at high speed, and their pH was measured.

RESULTS & DISCUSSION

THE EFFECTIVENESS of different levels of acidification was determined by comparing pH changes in the 40 products tested. The unacidified products had pH values between 4.34 and 4.66. With seven products, prepared according to home canning recipes calling for acidification, addition of the specified acidulants (5.3–27.8 ml lemon juice, vinegar, or Worcestershire sauce per pint) resulted in pH values between 4.15 and 4.46. Six additional products, containing acidulants as specified by their recipes but not intended for home canning, gave pH values between 4.06 and 4.63. Clearly, acidification specifications given in the latter recipes will produce a wide range of pH values and cannot be relied on to lower the pH sufficiently to permit water bath processing.

The regression equation we used to predict the quantity of vinegar required to lower the pH of combinations to 4.4 is represented by:

$$\text{ml vinegar per 100g mixture} = \sum_{i=0}^9 \beta_i X_i + \sum_{j=1}^9 \beta_{0j} X_0 X_j$$

where the regression coefficients β_i and β_{0j} and ingredient percentages X_i and X_j for ingredients i and j are defined in Table 2. The R^2 value and standard error of the estimate for the regression were 0.929 and 1.6 ml/100g, respectively. Acidification levels predicted by the regression equation were between 6.1 and 12.7 ml vinegar per pint of product. The acidified combinations gave pH values varying from 4.22 to 4.50, the mean and standard deviation being 4.36 and 0.08 pH units, respectively. Although the mean pH of

these samples was close to the target pH (4.4), the error inherent in the regression equation would result in some pH values being appreciably higher than the target.

Vinegar addition levels obtained by our "worst case" analysis were usually intermediate between the levels determined by titration to pH 4.4 and 4.2 (Table 1). Thus, all products acidified using the "worst case" estimate had an equilibrated pH ≤ 4.4 . Furthermore, all but four of these products were acidified below pH 4.3, which would theoretically inhibit flat-sour spoilage by *Bacillus coagulans* (Rice and Pederson, 1953). The vinegar additions recommended in Table 1 are the "worst case" acidification levels adjusted to common household units for each product category. These acidification levels were found to reduce the equilibrium pH by 0.2 to 0.3 pH units in combination products having pH values close to 4.6 before acidification.

The acidification guidelines developed herein may be used by extension specialists and other food preservation experts who disseminate home canning information to the public. We must stress that these recommendations are applicable only to high-acid food products. Acidification should not be used as a means of changing a low-acid combination into a high-acid product so that a boiling water bath process could be used in place of pressure canning. Such a procedure would be inherently unreliable in the home, even presenting a potential risk of botulism since home canners generally lack the means to measure pH, cannot anticipate and compensate for variability in ingredient buffering properties or acidity, and may inadvertently or intentionally deviate from a recommended recipe.

We expect the acidification recommendations made herein to be compatible with product flavor. Many published recipes for tomato-based combinations already specify comparable levels of acidification, and acidification to attain similar pH values is widely used commercially for canned tomato products, pepper products, and sauces. Should a flavor problem be encountered with vinegar, bottle lemon juice could be substituted, using approximately two-thirds as much, since citric acid is a more effective acidulant and imparts less flavor than acetic acid (Sapers et al., 1978). If a marginally high-acid product cannot be acidified adequately without adversely affecting its flavor, the product should be preserved by freezing or by pressure canning, using a process appropriate to the low-acid ingredients.

REFERENCES

- Powers, J.J. 1976. Effect of acidification of canned tomatoes on quality and shelf life. *Critical Reviews in Food Science & Nutrition*. June: 371.
- Rice, A.C. and Pederson, C.S. 1953. Factors influencing growth of *Bacillus coagulans* in canned tomato juice. 2. Acidic constituents of tomato juice and specific organic acids. *Food Res.* 19: 124.
- Sapers, G.M., Phillips, J.G., and DiVito, A.M. 1982a. Equilibrium pH of home canned foods comprising mixtures of low-acid and high-acid ingredients. *J. Food Sci.* 47: 277.
- Sapers, G.M., Phillips, J.G., DiVito, A.M., and Brooks, W.M. 1982b. Model for predicting the pH of foods comprising mixtures of tomatoes and low-acid ingredients. *J. Food Protection*. 45: 566.
- Sapers, G.M., Phillips, J.G., Talley, F.B., Panasiuk, O., and Carre, J. 1978. Acidulation of home canned tomatoes. *J. Food Sci.* 43: 1049.

Ms received 4/14/82; revised 4/19/82; accepted 6/17/82.

The authors thank Lucille K. Conway, Grace T. Maher, and Jaroslav Dykyl for their technical assistance.

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